CLAIMS

1. Transportable cooling unit for maintaining a transport volume at a defined temperature, comprising
a closed cooling circuit serially including a multi-stage compressor, a condensor, an expansion device and an evaporator arranged in said transport volume,
a speed controlled electric motor driving said compressor,
and a controller sensing a temperature present within said transport volume and controlling said electric motor so as to provide the heating or cooling power demanded at said evaporator for maintaining said defined temperature and minimizing energy consumption, said controller operating said closed cooling circuit between a maximum possible heating power and a maximum possible cooling power in a sequence of different operational stages comprising a lowest operational stage and a sequence of at least two upper operational cooling stages,
said controller operating said closed cooling circuit in each one of said upper operational cooling stages at a compressor speed related cooling capacity different from said compressor speed related cooling capacity in said other upper operational cooling stages,
and within said respective upper operational cooling stages said controller operating said electric motor in an uninterrupted mode and adjusting said cooling power provided by said closed cooling circuit by an essentially stepless speed control of said electric motor.

2. Cooling unit according to claim 1, wherein said speed controllable electric motor is a frequency controlled AC-motor.

3. Cooling unit according to claim 1, wherein in said closed circuit heating power is obtained in addition to cooling power by providing an inoperable mode of said condenser in addition to an operable mode of said condenser.

4. Cooling unit according to claim 3, wherein said inoperable mode of said condenser provides bypassing said condenser.

5. Cooling unit according to claim 4, wherein said inoperable mode of said condenser also provides by-passing of said expansion device.

6. Cooling unit according to claim 4, wherein a by-pass pipe is provided and wherein a valve is provided which enables changes between the operable mode of said condenser combined with an inoperable bypass pipe and the inoperable mode of said condenser combined with an operable bypass pipe.

7. Cooling unit according to claim 3, wherein said controller operates said compressor in said lowest operational stage in an uninterrupted mode at low speed and operates said closed cooling circuit by changing between the operable and inoperable mode of said condenser according to respective mode intervals and adjusts said cooling or heating power by adjusting at least one of the parameters comprising speed of said compressor and duration of said mode intervals.

8. Cooling unit according to claim 7, wherein said controller in said lowest operational stage maintains said speed of said electric motor essentially constant and varies the duration of said mode intervals.

9. Cooling unit according to claim 8, wherein in said lowest operational stage said constant speed of said electric motor is in the dimension of the minimum possible speed of said compressor.

10. Cooling unit according to claim 3, wherein said mode intervals are generated by controlling a hot gas valve in said bypass pipe to said condenser.

11. Cooling unit according to claim 1, wherein said controller defines the cooling power demanded by comparing the temperature present within said transport volume and the requested temperature in said transport volume.

12. Cooling unit according to claim1, wherein said controller senses the temperature in a stream of air circulating within said transport volume.

13. Cooling unit according to claim 12, wherein said controller senses the temperature within said transport volume close to said evaporator.

14. Cooling unit according to claim 1, wherein said controller selects the currently necessary operational cooling stage in accordance with the cooling power demanded and adjusts the speed of the compressor for precise adjustment of the cooling power provided by said closed cooling circuit.

15. Cooling unit according to claim 1, wherein said compressor speed related cooling capacity of said closed cooling circuit with the condenser being in the operable mode is constant within said lowest operational stage.

16. Cooling unit according to claim 1, wherein said compressor speed related cooling capacity of said closed cooling circuit with the condenser being in the operable mode is constant within at least one of said upper operational cooling stages.

17. Cooling unit according to claim 1, wherein said compressor speed related cooling capacity of said closed cooling circuit in said lowest stage with the condenser being in said operable mode is the same as the compressor speed related cooling capacity in said one of said upper operational cooling stages covering the lowest range of cooling power of said sequence of upper operational stages.

18. Cooling unit according to claim 1, wherein the controller switches from one upper operational stage cooling to another upper operational cooling stage with a hysteresis with respect to the level of cooling power.

19. Cooling unit according to claim 18, wherein in the course of a transition from one of said upper operational cooling stages to another of said upper operational stages said controller maintains full control of the cooling power provided by said closed cooling circuit by adjusting the speed of said compressor in accordance with the change of the compressor speed related cooling capacity.

20. Cooling unit according to claim 1, wherein said multi-stage compressor is operable in a first mode using a reduced number of compressor stages or in a second mode using all compressor stages.

21. Cooling unit according to claim 20, wherein said multi-stage compressor is controllable by said controller so as to be operated in said first mode or in said second mode.

22. Cooling unit according to claim 21, wherein in one of said upper operational cooling stages of said closed cooling circuit said compressor operates in said first mode and in another of said upper operational cooling stages of said closed cooling circuit said compressor operates in said second mode.

23. Cooling unit according to claim 22, wherein said controller switches from an operational cooling stage in which the compressor operates in said first mode to the operational cooling stage in which the compressor operates in said second mode at a defined level of cooling power which is higher than the defined level of cooling power at which the controller switches from the operational cooling stage in which the compressor operates in said second mode to the operational cooling stage in which the compressor operates in said first mode.

24. Cooling unit according to claim 1, wherein an economizer is provided in said closed cooling circuit.

25. Cooling unit according to claim 24, wherein said economizer can be switched by said controller between an economizer on-mode and an economizer off-mode.

26. Cooling unit according to claim 25, wherein in at least one of said upper operational stages the closed cooling circuit is controlled to operate in an economizer off-mode or in an economizer on-mode.

27. Cooling unit according to claim 26, wherein said controller in said operational stage in which the closed cooling circuit can be operated in the economizer off-mode or in the economizer on-mode switches from the economizer off-mode to the economizer on-mode if the temperature of compressor exceeds a defined level.

28. Cooling unit according to claim 1, wherein an upper operational heating stage is provided and wherein within said upper operational heating stage said controller is operating said electric motor in an uninterrupted mode and adjusting said heating power provided by said closed cooling circuit by an essentially stepless speed control of said electric motor.

29. Cooling unit according to claim 28, wherein said compressor speed related heating capacity of said closed cooling circuit is constant within said upper operational heating stage.

30. Cooling unit according to claim 28, wherein a further upper operational heating stage is provided in which the heating power of said cooling circuit is increased by a heating device.

31. Refrigerated container comprising a thermally insulated housing enclosing a transport volume to be cooled,
a cooling unit for maintaining said transport volume at a defined temperature, said cooling unit comprising

a closed cooling circuit serially including a multi-stage compressor, a condensor, an expansion device and an evaporator arranged in said transport volume,

a speed controlled electric motor driving said compressor,

and a controller sensing a temperature present within said transport volume and controlling said electric motor so as to provide the heating or cooling power demanded at said evaporator for maintaining said defined temperature and minimizing energy consumption, said controller operating said closed cooling circuit between a maximum possible heating power and a maximum possible cooling power in a sequence of different operational stages comprising a lowest operational stage and a sequence of at least two upper operational cooling stages,

said controller operating said closed cooling circuit in each one of said upper operational cooling stages at a compressor speed related cooling capacity different from said compressor speed related cooling capacity in said other upper operational cooling stages,

and within said respective upper operational cooling stages said controller operating said electric motor in an uninterrupted mode and adjusting said cooling power provided by said closed cooling circuit by an essentially stepless speed control of said electric motor.